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ABSTRACT

Although the most desired attributes of a geographer are spatial perception and verbal ability, research reveals that each sex consistently demonstrates superiority in only one of the abilities. In the United States females score significantly higher in verbal abilities and males score significantly higher in spatial abilities. The differences are attributed either to cultural or physiological causes; in either case the possibility of effecting change is remote. The implications for the discipline of geography are far reaching. One must question whether geography is destined to remain a small science because of the lack of people who possess the appropriate dual cognitions. Geographers must be concerned with whether one of these abilities is more important than the other and whether geography has a lower potential for producing top quality work than other sciences. Finally, although geographers must look for those few individuals with a high degree of verbal and spatial ability, they must also be aware that learning experiences can modify existing situations. (KC)

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GEOGRAPHY:

THE SCIENCE MOST AFFECTED BY EXISTING SEX-DIMORPHIC COGNITIVE ABILITIES

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Abstract

For more than fifty years, test have consistantly shown that females as a group test significantly lower than males as a group in the area of spatial perception and that males test significantly lower than females in verbal abilities. In this paper, the results of work done to find the causes of these sex-dimorphic cognitive abilities are summarized and possible far-reaching ramifications are presented suggesting that, perhaps more than any other science, geography is affected by these circumstances.

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THE SCIENCE MOST AFFECTED BY EXISTING SEX-DIMORPHIC COGNITIVE ABILITIES

by

Jeffrey Dean Maddux

A phenomenon exists in this and other countries that should be of concern to those interested in the growth of geography. Geographers either have taken little notice or are not aware of it. Those researchers in other sciences who have measured this phenomenon for over five decades have as of yet not thought to enlighten geographers, who are perhaps most affected. The existence of this phenomenon has been well documented by other researchers and its existence is an accepted fact. The intent of this paper is primarily to expose this situation and what is known about the causes, plus the possible continually debilitating consequences for geography.

This situation lies in the measurable differences between the sexes in certain cognitive abilities. In this country, females test

significantly lower than males in spatial perception[1] and males test significantly lower than females in verbal ability (fluency,

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[1]Anne Anastasi, Differential Psychology, 3rd ed. (New York, Macmillan, 1958), p. 472. G. K. Bennett and Ruth M. Cruikshank, "Sex Differences in the Understanding of Mechanical Problems", Journal of Applied Psychology, v.26 (1942), pp. 121-127. G. K. Bennett, H. G. Seashore, and A. G. Wesman, Differential Aptitude Tests: Manual, 2nd ed. (New York, Psychology Corp., 1952). A. A. Ehrhardt and H. F. L. Meyer-Bahlburg, "Effects of Prenatal Sex Hormones on Gender-Related Behavior", Science, v. 211 (1981), p. 1317. R. J. Havighurst and Fay H. Breese, "Relation Between Ability and Social Status in a Midwestern Community: III. Primary Mental Abilities", Journal of Educational Psychology, v. 38 (1947), pp. 241-247. F. Herzberg and M. A. Lapkin, "A Study of Sex Differences on the 'Primary Mental Abilities' Test", Educational Psychology Measurement, v. 14 (1954), pp. 687-689. J. R. Hobson, "Sex Differences in Primary Mental Abilities", Journal of Educational Research, v. 41 (1947), pp. 126-132. E. E. Maccoby and C. N. Jacklin, The Psychology of Sex Differences (Stanford, Ca., Stanford University Press, 1966 (and 1974)), 1st (and 2nd) ed., p. 26. Agnes M. Macmeeken, The Intelligence of a Representative Group of Scottish Children (London, University of London Press, 1939). Q. McNemar, The Revision of the Stanford-Binet Scale: An Analysis of the Standardization Data (Boston, Houghton Mifflin, 1942). D. G. Paterson, et al., Minnesota Mechanical Ability Tests (Minneapolis, University of Minnesota Press, 1930). S. D. Porteus, "The Measurement of Intelligence: 643 Children Examined by the Binet and Porteus Tests", Journal of Educational Psychology, v. 9 (1918), p. 13-31. C. I. Sandström, "Sex Differences in Localization and Orientation", Acta Psychology, v. 9 (Sweden, 1953), pp. 82-96. R. R. Sears, M. H. Pintler, and Pauline S. Sears, "Effect of Father Separation on Preschool Children's Doll Play Aggression", Child Development, v. 17 (1946), pp. 219-243. Deborah P. Waber, "Sex Differences in Cognition: A Function of Maturation Rate?", Science, v. 192 (1976), pp. 572-574. Deborah P. Waber, Developmental Psychology, v. 13 (1977), p. 29. P. E. Webb, "A Study of Geometric Abilities Among Boys and Girls of Equal Mental Abilities", Journal of Educational Research, v. 15 (1927), pp. 256-262. H. A. Witkin, et al., Personality Through Perception (New York, Harper, 1954).

articulation, and perceptual speed).[2] All research reviewed on this topic show better than a .05 significance level. Even when the overall I.Q.s of the test males and females were closely matched, the results were still significant.[3] For example, a very reliable difference in verbal abilities was found when S.A.T. verbal section scores were compared on the basis of sex (with a t value of 13.52).[4] Females as a group demonstrate superior verbal abilities from their first word to adulthood.[5]

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[2]Anastasi. Bennett and Cruikshank. Bennett, Seashore, and Wesman. Ehrhardt and Meyer-Bahlburg. Havighurst and Breese. Herzberg and Lapkin. Hobson. L. L. LaBrant, "A Study of Certain Language Developments of Children in Grades Four to Twelve Inclusive", Genetic Psychology, Monograph, No. 14 (1933), pp. 387-491. Maccoby. Dorothea McCarthy, "The Language Development of the Preschool Child", University of Minnesota Institute for Child Welfare, Monograph, No. 4 (1930). Dorothea McCarthy, "Language Development", Ch. 8 in Handbook of Child Psychology, C. Murchison, ed. (Worchester, Mass., Clark University Press, 1933), pp. 956. Dorothea McCarthy, "Some Possible Explanations of Sex Differences in Language Development and Disorders", Journal of Psychology, v. 35 (1953), pp. 155-160. Dorothea McCarthy, "Language Development in Children", in Manual of Child Psychology, 2nd ed., L. Carmichael, Ed. (New York, Wiley, 1954), pp. 492-630. H. Schnell, "Sex Differences in Relation to Stuttering: Part I", Journal of Speech Disorders, v. 11 (1946), pp. 277-298. H. Schnell, "Sex Differences in Relation to Stuttering: Part II", Journal of Speech Disorders, v. 12 (1947), pp. 23-38. L. M. Terman and Leona E. Tyler, "Psychological Sex Differences", in Manual of Child Psychology, 2nd ed., L. Carmichael, Ed. (New York, Wiley, 1954), pp. 1064-1114. Waber, Science. A. G. Wesman, "Separation of Sex Groups in Rest Reporting", Journal of Educational Psychology, v. 40 (1949), pp. 223-229.

[3]Anastasi, p. 476. Webb.

[4]Anastasi, p. 423.

[5]Maccoby. McCarthy, Handbook of Child Psychology, 1st ed. (1933). Differences in the verbal scores, however, tend to close slightly between the sexes around the late elementary level and during the last two years of high school. Many researchers are quick to point out that during the high school period, males are more likely to drop out of school. Thus, they argue that many more of the potentially low test scores are eliminated from the male population being tested. Plus, the evidence demonstrates that, even through college, males as a group test as high as females in verbal ability.

Males show little superiority in spatial perception until the age of six.[6] However, a sex difference in this type of cognitive ability is not only measurable in early elementary school children, but the differences have been shown to accelerate during puberty.[7] This phenomenon exists on top of the fact that spatial cognition tests lower than most other cognitive abilities among the American population as a whole[8], a fact that geographers have been reporting for years. The results shown in the Figure are based on one type of spatial test and are not unlike other spatial test results for teenagers and older groups.

In Ehrhardt and Meyer-Bahlburg's 1981 survey of the evidence concerning gender-related behavior, they point out what behaviors may or may not be attributed to hormonal influences.[9] In the area of cognitive sex differences, the only possible physiological correlation related to hormonal differences as of yet demonstrated is with patients with congenital adrenal hyperplasia, also known as CAH.[10] In sampled CAH individuals the only noted cognitive

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[6] A. Gesell, et al., The First Five Years of Life (New York, Harper, 1940), Maccoby.

[7] Maccoby. Peterson. Waber, Science, pp. 572-574.

[8] i.e., David Hill, "Curricular Implications of a National Survey of Global Understanding", Paper presented at the 1981 A. A. G. Annual Meeting, Los Angeles; Abstract published in the AAG Abstracts Los Angeles 1981 (Kanebeck Enterprises, 1981).

[9] For instance, gender identity seems to be almost totally learned, sex-dimorphic behavior and temperamental sex differences appear to be modified by prenatal sex hormonal variences, and there may or may not be a partial correlation between the development of erotic partner preference as in hetero-, homo-, or bisexual orientation and the functioning levels of various endocrine glands. Ehrhardt and Meyer-Bahlburg, pp. 1312-1318.

[10] This genetic disorder prevents the adrenal cortices from synthesizing cortisone and causes an excess release of adrenal androgens from fetal life onward. P. A. Lee, L. P. Plotnick, A. A. Kowarski and C. J. Migeon, Eds., Congenital Adrenal Hyperplasia (Baltimore, University Park Press, 1977).

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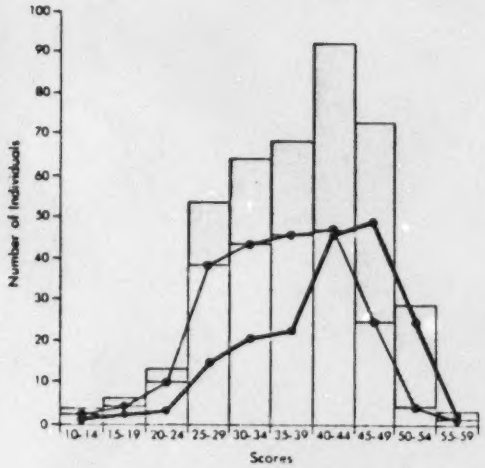

Boys ▭ ——

Girls ▭ ——

1. P.E. = S.E. × .6745 = .58

$$S.E. = (S.D. = \frac{\sqrt{\Sigma d^2}}{N}) \frac{}{\sqrt{N}}$$

2. Mean scores: 40.39 (Boys)
   − 35.9 (Girls)
   4.58

3. Critical Ratio = $\frac{4.58}{.58} = 7.9$

Figure 1. A general rendition of a set of results obtained from one type of spatial ability test for a group of late adolescents. Based on Anastasi (1) and Webb (43).

difference is lower number ability (or arithmetic skill),[11] which most but not all researchers believe to be a sex-dimorphic ability.[12] Cognitive data on prenatal hormone effects on sex-dimorphic cognitive abilities also offer either tentative[13] or no support at all[14] for physiological causes.

Although no relationship between physical maturation rates and general intellectual growth has ever been shown,[15] Deborah Waber has found that early maturing adolescents performed better on tests of verbal than spatial abilities ($P<.001$) and late maturing adolescents showed the opposite pattern ($P<.001$), regardless of sex. The significance level was better than .001. Sex differentiation was not significant, using the ($P>$) .05 level, within maturation groups.[16] Based on this evidence, she argues that the often measured sex differences in mental abilities reflect differences in the organization of cortical function that are

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[11] S. W. Baker and A. A. Ehrhardt, in Sex Differences in Behavior, R. C. Friedman, R. M. Richart, and R. L. Vandewiele, Eds. (New York, Wiley, 1974), pp. 53-76. V. G. Lewis, J. Money, and R. Epstein, Johns Hopkins Medical Journal, v. 122 (1968), p. 192. S. M. Perlman, Journal of Learning Disabilities, v. 6 (1973), p. 26.

[12] Ehrhardt and Meyer-Bahlburg, for example, contend it is not a sex-dimorphic ability. Ehrhardt and Meyer-Bahlburg, p. 1317. Webb, however, shows a C.R. of 7.9 in spatial math (geometry) ability in favor of males (see Figure 1) and Anastasi shows a C.R. = 11.59 on S.A.T. math scores. Anastasi, pp. 421-478. Webb. Not only is there a lack of consensus as to whether or not number ability is sex-dimorphic (unlike verbal and spatial abilities), but the measured significance levels when demonstrated are always lower than for the other two abilities.

[13] D. N. Masica, J. Money, A. A. Ehrhardt, and V. G. Lewis, Johns Hopkins Medical Journal, v. 124 (1969), p. 34. I. D. Yalom, R. Green, and N. Fish, Archives of General Psychiatry, v. 28 (1973), p. 554.

[14] A. Lynch, W. Mychalkiw, and S. J. Hutt, Early Human Development, v. 2 (1978), p. 305. H. F. L. Meyer-Bahlburg and A. A. Ehrhardt, in Progress in Sexology, R. Gemme and C. C. Wheeler, Eds. (New York, Plenum, 1977), pp. 85-92. J. U. Zussman, P. P. Zussman, and K. Dalton, Abstract, Meeting of the Society for Research in Child Development, Denver, Colo., 1975; J. U. Zussman, P. P. Zussman, and K. Dalton, Abstract, Third Annual Meeting of the International Academy of Sex Research, Bloomington, Ind., 1977.

[15] Nancy Bayley, "Some Psychological Correlates of Somatic Androgyny", Child Development, v. 22 (1951), pp. 47-60.

[16] Waber.

related to differential rates of physical maturation.[17] In other words, her studies indicate that these sex-dimorphic abilities will continue as long as females generally attain physical maturity at an earlier age than males.[18]

Collaborating Waber's findings for the development of spatial abilities, McGlone and Davidson show a correlation along a continuum of rate of maturation, regardless of sex.[19]

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[17] Ibid.

[18] She further showed that among groups of late maturing ten year old and thirteen year old males and females, the mean test scores for all four groups were between 30% and 45% higher on the spatial portion than on the verbal portion. Late maturing individuals were those that possessed a chronological age at least one standard deviation above the mean age for their stage of sexual development according to norms reported by Marshall and Tanner. W. A. Marshall and J. M. Tanner, Archives of Diseases in Childhood, v. 44 (1969), p. 291. Ibid, v. 45 (1970), p. 13. Among early maturers whose chronological age was at least one standard deviation below the mean age for their stage of sexual development, the difference between verbal and spatial mean scores were 35% to 40% greater with both the male and female thirteen year olds than with their ten year old male and female counterparts. The mean scores for the two thirteen year old groups were 40% (for the females) and 70% (for the males) higher on the verbal sections than on the spatial sections. Waber. Tests for which sex differences in the appropriate direction had previously been reliably reported were used by Waber to assess mental abilities. Maccoby, 1st ed. (1966), pp. 25-55. The Digit Symbol subtest of the Wechsler Intelligence Scale for Children (WISC), the Color-Naming subtest of the Stroop Color Word test and the Word Fluency subtest of the Primary Mental Abilities (PMA) test measured verbal ability; the Block Design subtest of the WISC, the Embedded Figures test, and the Spatial Abilities subtest of the PMA measured spatial ability. For more details on these tests see: Waber, pp. 573-574.

[19] J. McGlone, W. Davidson, et al., Neuropsychologia, v. 11 (1973), p. 105. J. McGlone and A. Kertesz, Cortex, v. 9 (1973), p. 313. R. Remington, S. Krashen, and R. Harshman, paper presented at the 86th Annual Meeting, Acoustical Society of America, Los Angeles, 1973.

In concordance with these findings, Levy postulates that since language is primarily a function of the left cerebral hemisphere and spatial processing is believed to be the province of the right hemisphere, that development of one specialization may actually interfere with the development of the other.[20] Easily observable examples of this type of phenomenon are people who are taught to use their right hand over their left. By late adolescence, so much time and training has gone into the development of motor skills with the right hand, it is unlikely that most right-handers would ever attempt to develop their left hand as highly, assuming it is even possible. The same is most likely true of left handers. Regardless of whether or not ambidextrous people have developed both sides of the brain equally in regards to manipulative skills, the relative size of this population as compared to the overall population does not speak favorably for the likely development of other hemispherically dimorphic functions.

Anthropologists and other scientists have noted varying degrees of lower spatial perception among females in other cultures as well. Of these field researchers, those who choose to speculate as to why this sex-dimorphic cognition exists usually point to the differences in learning experiences between the sexes as a result of cultural structures (or dictates), including sex-role assignments. This agrees

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[20] For example, a person may spend much of their training as a youth developing concrete abilities such as logical reasoning, which in turn may detract from that person's training and ability for creating abstract ideas such as impressionistic art. The above training and development might be the opposite for another individual. J. Levy, Nature, v. 224 (London, 1969), p. 614.

with researchers, other than Waber, Levy, or McGlone and Davidson, who believe that sex-dimorphic cognition is primarily, if not totally, learned.[21]

What do these sex-dimorphic cognitive abilities mean to geography? Logic suggests and research verifies that people tend to enjoy and are attracted to the activities they do best and tend to avoid those activities that entail a higher risk of failure or poor performance. This is illustrated by high school and college elective course selections. If approximately 70% of the female college population in this country test lower than the average male in spatial perception, then (all other factors being equal) will female enrollment in geography courses tend to be lower than male enrollment?

How important is spatial perception to geography? Although it may be impossible to draw a consensus on any one definition for geography, Kant defined it as the study of spatial variations, and the spatial point of view is generally held to be more important to and by geographers than among most other scientists.[22] To quote a more contemporary example, McDonald states that "geography is above all that

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[21]For example, Ehrhardt and Meyer-Bahlburg, p. 1317. Since these sex-dimorphic cognitions are shared traits in those parts of the U.S. where populations have been tested, any differences that are due to sex-dimorphic learning experiences would tend to implicate as of yet unidentified elements of American culture as causal factors.

[22]J. G. Jordan and L. Roundtree, The Human Mosaic (San Francisco, Canfield Press, 1976), pp. 1-3. Robert Huke and Vincent Malmstrom, Geography as a Discipline (Washington, D.C.: Association of American Geographers, 1973), p. 1.

field of learning which deals with spatial relationships".[23] Alexander and Gibson even go so far as to suggest that perhaps 'spatial science' or 'areal science' might be a more appropriate name than 'geography'.[24] Many geographers would also agree that the spatial point of view is the factor that makes geography unique from most other sciences. As Broek and Webb put it, "'where' is the first thing the geographer wants to know," which "requires defining its spatial relationship to other points".[25] Others claim that it is place, area, or the spatial concept known as the 'region' that is the unique conceptual core to the science of geography.[26] Some, however, would argue that spatial cognition is not an important component of geography.

On the other hand, how much does verbal ability compensate for a lack of spatial ability? Educators and psychologists have repeatedly pointed to verbal skills as being the most important indicator of overall academic success from the first grade through college. If the college-bound female population tests higher than males in verbal abilities, are they then likely to do as well or better than males in geography courses?

Which is more important to geographers, spatial or verbal skills?

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[23]James R. McDonald, A Geography of Regions (Dubuque, Iowa, Wm. C. Brown Company Publishers, 1972), p. 1.

[24]John W. Alexander and Lay James Gibson, Economic Geography, 2nd ed. (Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1979), p. 6.

[25]Jan O. M. Broek and John W. Webb, A Geography of Mankind (New York, McGraw-Hill, 1968), p. 6.

[26]Robert H. Fuson, A Geography of Geography (Dubuque, Iowa, Wm. C. Brown Company Publishers, 1969), p. 104. 'Place' or 'area' are two other terms commonly used to define geography. Hettner Vidal de la Blache, Preston James, Hartshorne, etc. as cited in Richard Hartshorne, Perspectives on the Nature of Geography (Chicago: Rand McNally & Co., 1959), pp. 13-14, 47. Also see Preston E. James, All Possible Worlds: A History of Geographical Ideas (Indianapolis: The Odyssey Press, 1972), pp. 13-14, 186-187, 218-220.

For dynamic growth, every science needs individuals who can both cognitively perceive new understanding within their science and articulate that understanding. If only the top 10% of the tested individuals in each of the two abilities are considered, it is shown that in spatial perception, males outnumber females 3:1 and in verbal ability, females outnumber males at least 2:1. How many individuals scored high simultaneously in both abilities is not known because the non-geographer-researchers who have tested these and other abilities primarily along sex lines have never reported on that particular correlation. However, the probability that these two cognitive abilities are possessed to a high degree within the same individual is very low, based on such opposing sex-dimorphic curves alone. The probability appears even lower if Waber's and Levy's assumptions about the physiological conditions most conducive to a high level of development for each ability are correct.[27] Whether the cause is cultural, physical, or both, the end result seems to be that the presence of the type of dual cognition most appropriate for geographers is perhaps rarer than for any other science.

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[27]Based on their findings, to significantly increase the small number of people who possess a high level of ability in the two cognitive areas most important to geography would require a change in the laws of nature. Based on other researchers conclusions, to effect the same change would require the improbable task of changing as of yet unidentified aspects of our culture.

Could it be that geography is destined to remain a small science due to a lack of people possessing the appropriate dual cognitions? Is one sex more likely to simultaneously possess these two traits than the other sex? Can high verbal ability substitute for low spatial perception or vice versa? Is one of these abilities more important than the other for being a successful geographer? Does geography as a science have a lower potential for producing the same amount of top quality work as other sciences? These are some of the unanswered questions yet to be dealt with. But the first and foremost question that needs to be answered is what relationship do those abilities tested by psychologists and educators have with the abilities most useful to geographers and their students? This in turn necessitates an analysis of what it is the standardized tests actually test, plus a determination of what abilities are truly most useful for geographic understanding. No doubt the relevance of abilities varies with the type of geography being considered.

Regardless of the results of such studies, it is possible that learning experiences can act as an agent for successfully modifying the existing situation. For example, children with a high degree of athletic ability are more likely to pursue soccer or any other sport, much as children with high academic ability are more likely to pursue geography or any other discipline. In high school and college, soccer coaches look for those rare youth who have developed a high degree of skill with both legs, just as geography advisors might watch for those

rare individuals with a high degree of verbal and spatial talent. However, most people are more competent with either the left or right leg than with the other. The same is true with verbal and spatial abilities. Soccer coaches also actively pursue youth that are extremely proficient with one leg and just as actively attempt to motivate those youth to develop the talent of the other leg. Do geographers attempt the same strategy with their students? Professional soccer players still generally play better with one leg than the other, but they have had to also develop a high degree of competence with the weaker leg in order to be successful. Is the same true for geographers? And, who are the better soccer players, the ones with a dominant right foot or a dominant left foot? Perhaps it is just as irrelevant a question as who make the best geographers? It is, however, important to know that differences in the level of a person's individual skills, regardless of whether the causes are physical, environmental, or both, is normal and that proper training can improve all of the appropriate skills, but equally high verbal and spatial abilities is not normally to be expected, regardless of training.[28]

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[28]Perhaps geography can learn another lesson from soccer. Somewhat like geography, the sport of soccer is small and little appreciated in this country, at least it was ten years ago. With most adult sport fans already loyal to football, or whatever other sports, soccer faces perhaps an insurmountable task in trying to convert into fans large numbers of adults with little or no experience or knowledge of the sport. However, within the last ten years, youth soccer programs have been very successful in this country for a number of reasons, including the fact that both girls and boys can participate. If the youth programs continue, soccer will continue to grow in the number of high schools and colleges that participate in the sport (as is already happening) because students and their parents will insist on it. As the ranks of the adult population begin to fill with people with soccer experience, the sport will become a major American institution, as it already is in virtually every country outside of the U.S. and Canada. Could geography do something similar?

The situation presented herein may not be a pleasant realization for geographers who would like to see their science grow significantly, particularly in the next couple of decades, but it is important for geographers to know as much as possible about what they are actually up against if they expect to struggle with any degree of success for the growth of their science.